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recently accepted the post of Government Botanist in charge of the botanical section of the Biological Commission of the Department of Agriculture and of the Bureau of Forestry in Mexico.

DISCUSSION AND CORRESPONDENCE

SOILS AND CROPS

IF we accept Professor Chamberlin's view, "that the total eon of productive soils may be assigned a period of at least tens of millions of years" (as expressed in his article on "Soil Productivity" in *SCIENCE*, February 10, 1911, and if we accept his endorsement of Cameron's estimate for the United States that the capillary waters are carrying potassium toward the surface at the rate of from 40 to 83 pounds per acre per annum, while the total average removal amounts to only 23 pounds (20 pounds in crops and 3 pounds in drainage), then we might expect the potassium to accumulate in the surface soil at the rate of 1,700 to 6,000 pounds per acre per century, or at the rate of 17,000 to 60,000 pounds per thousand years, on normal level lands not subject to surface erosion; we might expect the surface soils to be many times richer in potassium than the corresponding subsoils, and the older soils to be much richer than those of more recent but similar origin.

In contrast with these theoretical deductions the science of chemistry reveals the facts,¹ for example, that the common prairie lands of the oldest Illinoian Glaciation contains as an average 12,470 pounds of potassium per million of dry surface soil and 14,050 pounds per million of the subsoil; that the more recent Early Wisconsin Glaciation contains 18,120 pounds in the surface and 19,650 pounds in the subsoil; and that the Late Wisconsin Glaciation contains 22,510 pounds in the surface and 26,690 in the subsoil.

The corresponding timbered soil types contain, in the oldest Illinoian Glaciation, 15,100 pounds of potassium (per million of dry soil) in the surface and 16,050 pounds in the

subsoil; while in the Early Wisconsin Glaciation the respective amounts are 18,080 and 21,100; and in the Late Wisconsin Glaciation there are 23,800 pounds in the surface and 26,100 in the subsoil, per million of dry soil.

If two inches of water soak into a soil and if one inch escapes by evaporation and the other by subdrainage, the net result is not gain but loss of soluble minerals, under normal conditions. In level or slightly undulating upland areas, such as the loess-covered prairies of the Central-West, which neither receive deposits from overflow nor lose partially depleted soil by erosion (especially while protected by prairie grasses), the operation of the natural law tends steadily toward soil depletion, with respect to the mineral elements; and this law has been in operation since the glacial or loessial age, wherever the climatic conditions have been similar to those now prevailing in our humid sections. The accumulation of organic matter (including some phosphorus) in such glacial or loessial soil begins some time after its deposition and continues until a maximum is reached, after which the organic matter, as well as the valuable mineral elements, tends to decrease, the latter because of leaching, as from the beginning, and the former because the rate of decay finally exceeds the rate of growth or accumulation.

That phosphorus is an essential constituent of the living tissues of plants and that it accumulates in plant residues in prairie soils are well-established facts, but a theory that the phosphorus brought to the surface in capillary moisture exceeds that removed by crops and drainage is not supported by the composition of soils of similar origin and different age. Thus ultimate analysis shows per million of dry surface soil 420 pounds of phosphorus in the oldest Illinoian Glaciation, 595 in the more recent Early Wisconsin, and 705 pounds in the Late Wisconsin.

Even the theories of the federal Bureau of Soils and the estimates of the United States Department of Agriculture must be heavily discounted if they stand opposed to established facts; for one fact outweighs a thou-

¹ Illinois Experiment Station Bulletin 123 and unpublished data.

sand opinions based upon erroneous theories or estimates.

As a rule our meat is made from corn, and our bread from wheat. An average of the last five or six years compared with an average of a like period ten years before reveals the following data taken from the Year Books of the United States Department of Agriculture:

1. The average annual production of corn in the United States increased during this ten-year period from 2074 million to 2733 million bushels.

2. The average exportation of corn from the United States decreased from 177 million to 67 million bushels.

3. Consequently, the average annual supply of corn for our domestic use increased from 1897 million to 2666 million bushels—an increase of 40 per cent.

Now, if we keep in mind that every figure here given is based upon an average of at least five years, and also keep in mind that the population of the United States increased only 21 per cent. from 1900 to 1910, then we may well ask, if the supply of corn for home use has increased 40 per cent. and the population only 21 per cent., what have we done with such an enormous surplus of corn retained in this country?

A study of the statistics for wheat reveals the following data:

1. The average annual production of wheat increased during the ten-year period from 528 million to 669 million bushels.

2. Our average exportation of wheat decreased from 185 million to 110 million bushels.

3. Consequently, the average annual supply of wheat for our domestic use increased from 343 million to 559 million bushels—an increase of 63 per cent.

Here, too, we may well ask, if the supply of wheat for our home use has increased 63 per cent. while the population increase is only 21 per cent., what have we done with a retained surplus of wheat amounting to 42 per cent. above the increase in our population?

Under the Illinois laws about fifteen hun-

dred township assessors report to the Illinois State Board of Agriculture the acreage of the various important farm crops grown in all the townships of the state. A comparison of two five-year periods, 1895 to 1899 and 1905 to 1909, shows that the average area of corn grown in Illinois increased in ten years from 6,950,000 to 7,340,000 acres, according to the assessors' returns, working under the same law during this entire period; whereas, according to the estimates reported by the United States Department of Agriculture, the Illinois corn area has increased from 6,910,000 to 9,700,000 acres. In other words, the state assessors report an increase of less than 6 per cent. while the federal report shows an increase of more than 40 per cent. in the average Illinois acreage of corn.

If we consider our three great grain crops, corn, oats and wheat, the Illinois state report shows the total average production to have decreased by 1 per cent. during this ten-year period, but the federal crop report credits Illinois with an increase of 41 per cent. in her production of grain during the same period.

For 1910 the Illinois State Board reports 281 million bushels of corn; while the U. S. Department reports 415 million bushels as the Illinois crop. Likewise the Ohio state officials report 105 million bushels, and the federal estimate credits the state of Ohio with 145 millions of corn produced in 1910.

All of these comparisons seem to reveal the influence of a strong spirit of optimism on the part of the federal department of agriculture, which, however, is supported neither by the assessors' report nor by the existence of any important reserve supplies, nor by the increased price of grain and meat and the high cost of plain living. In the last report of the United States Secretary of Agriculture it is stated that the value of our agricultural products rose from 4417 million dollars in 1898 to 8926 million dollars in 1910—an increase of more than 100 per cent. in twelve years; but shall we rejoice or weep when we consider that this enormous increase in value is not due to improvement of soil but to the estimated increase of acreage in crops and to

the actual increase in prices for food that must be paid by our own citizens?

On the other hand, even the crop "statistics" of the department of agriculture show that the average yield of corn per acre in the entire United States was 25.6 bushels for the twenty years 1870 to 1889, and only 24.9 bushels for the twenty years 1890 to 1909, an average decrease of 0.7 bushel; while the "statistics" for wheat show 12.2 and 13.6 bushels as averages for the corresponding periods, an increase of 1.4 bushels, with millions of acres of virgin wheat lands brought under cultivation. As an average the "statistics" show an increase of 7 per cent. in yield per acre for these two greatest food-grain crops; while our population actually increased 51 per cent. during the same period. Curves projected from these data may not be alarming to those of the present generation who have not yet felt the high cost of living, but they look less comfortable for our own children.

True optimism is admirable, but blind optimism is dangerous. The undersigned has great faith that permanent general prosperity and progress will ultimately be secured for the people of the United States—not that kind of existence enjoyed (?) by the densely populated sections of China, which requires frequent readjustments, as now in progress² with the certainty of a sudden reduction in population numbered by the million; not a condition under which men and even women gather "the katamorphic products of human

² Nanking, China, February 3, 1911.—That the deaths due to famine and the pestilence following in its wake will total a million before spring was the estimate submitted to the relief committee here to-day. Relief workers are aghast with the realization of the task before them. Even were they in receipt of unlimited contributions for relief, the missionaries, doctors and other volunteer workers would be almost hopeless in the face of two and one half millions of suffering people in the Anhui and Kiang Su provinces. The famine is an old story in China, but the most experienced relief workers declared to-day that the present prospect is the worst in many years.—*From Press Dispatch.*

food-consumption" for a year, in order to recover and return to the soil an amount of phosphorus per individual equal in value to that for which we now receive at our phosphate mines only two cents from the exporter; but we seek rather a higher civilization whose achievement shall be based upon a knowledge of the fact that to insure permanent prosperity we must increase production and limit reproduction—especially the reproduction of the unfit, whose support in penal and charitable institutions already consumes about half the total revenues of the state governments.

Even though the high civilization of the ancient Mediterranean countries "went down into the dark ages with laughter," all must recognize and admire the recent agricultural developments in western European countries; but shall we ignore the fact that for five million dollars we are exporting annually to Europe a quantity of our highest-grade phosphate sufficient for the production of 1400 million bushels of wheat, that would be worth at least a thousand million dollars to the oncoming generations of Americans?

It is true that Denmark produces 40 bushels of wheat per acre, compared with 14 bushels in the United States, but Denmark produces only 4 million bushels of wheat, and then imports 5 million bushels of wheat, 15 million bushels of corn, the same amount of barley, 800 million pounds of oil cake, as much mill foods, and large amounts of phosphates, saving and using the imported fertility; and paying for it all with profit by exporting hundreds of millions of pounds of butter and bacon to a country whose degree of prosperity is measured by her profits from trading upon the prosperity and poverty of other larger countries.

The fundamental doctrine of the United States bureau of soils is indeed a pleasant one, and highly important if true, but exceedingly dangerous and condemnable if not true. It reads as follows, in exact quotations:

1. "That practically all soils contain sufficient plant food for good crop yields; that this supply will be indefinitely maintained."—Bureau of Soils Bulletin (1903) 22, p. 64.

2. "There is another way in which the fertility of the soil can be maintained, viz., by arranging a system of rotation and growing each year a crop that is not injured by the excreta of the preceding crop."—U. S. Farmers' Bulletin (1906) 257, p. 21.

3. "The soil is the one indestructible, immutable asset that the nation possesses. It is the one resource that can not be exhausted; that can not be used up."—Bureau of Soils Bulletin (1909) 55, p. 66.

4. "From the modern conception of the nature and purpose of the soil it is evident that it can not wear out, that so far as the mineral food is concerned it will continue automatically to supply adequate quantities of the mineral plant foods for crops."—Bureau of Soils Bulletin (1909) 55, p. 79.

If again we turn from theory to science, we find at the Rothamsted Station in a four-year rotation, including always a legume crop, that the yield of turnips decreased from 10 tons in 1848 to less than 1 ton per acre as an average for the last 20 years; that the barley decreased from 46 bushels in 1849 to 14 bushels as an average for the last 20 years; that the clover has decreased from 2.8 tons per acre in 1850 to less than one half-ton average since 1890; and that the wheat produced 30 bushels in 1851, and 33 bushels average during the next 12 years, but only 24 bushels since 1890, and 20 bushels per acre since 1900.

As an average of the last twenty years the value of the four crops on the unfertilized land at Rothamsted is \$33.83 (from four acres), but where the same crops were grown on adjoining land to which mineral plant food had been applied the average value is \$76.83, the increase being 140 per cent. above the cost of the minerals. Let us thank God for Rothamsted, and be grateful that agriculture has some facts.

Likewise at State College, a four-year rotation, including clover, has been practised for nearly thirty years, but as an average of two consecutive 12-year periods the value of the four crops (corn, oats, wheat and hay) decreased from \$44.20 to \$32.72; but where mineral plant food was applied the crop

yields averaged 49 per cent. above the unfertilized yields.

Both the teaching of science as applied to agriculture and the practise of farming, in America, have suffered and still suffer from an insufficient accumulation of facts and from an over-production of theories and conclusions.

While famine is frequent in China and Russia and almost constant in India—the only great populous agricultural countries comparable with the United States in necessary self-dependence—and while the beautiful level upland Leonardtown loam soils of southern Maryland, near the city of Washington, still lie agriculturally abandoned, with only 80 pounds of total phosphorus and 500 pounds of total calcium per million in the surface soil (facts discoverable even in Bureau of Soils Bulletin 54), shall we encourage the Whitney-Cameron doctrine³ *that it is never necessary at any time to introduce fertilizing material into any soil for the purpose of increasing the amount of plant food in that soil?*

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BROWNIAN MOVEMENTS AND MOLECULAR REALITY

TO THE EDITOR OF SCIENCE: I have recently received a copy of Mr. F. Soddy's English translation of Professor Jean Perrin's paper on "Brownian Movements and Molecular Reality." Its perusal recalls to mind some ideas I have entertained for a number of years relative to a general physical theory based on very simple facts or principles. The earliest record I have of these ideas is in a memorandum note of November 10, 1897. In a letter of January 30, 1900, to Professor Peter S. Michie, of the department of philosophy, U. S. Military Academy, West Point, the ideas referred to were outlined rather more clearly and I also presented a brief statement of them under date of August 11, 1900, to the International Congress of Physics which was held at Paris in connection with the Universal

³ Hearings before the Committee on Agriculture of the United States House of Representatives (1908), page 446; or Ginn & Company's "Soil Fertility and Permanent Agriculture," page 315.